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LIFT AND DRAG ANALYSIS ON POLYETHYLENE /AEROKOTE/SILK/POLYESTER FABRIC COATED AIRCRAFT WING

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Abstract

The composite coating plays a major role in the aircraft wing to reduce the failures. The attachment joints are inevitable in any large structure like an airframe. The wings are the most important lift-producing part of the aircraft. Wings vary in design depending upon the aircraft type and its purpose. Remote controlled airplane models are of great importance in the present era. They are used by scientific, government and military organizations for experiments, gathering weather readings, aerodynamic modeling and testing, and as drones or spy planes. This paper deals with the design of wing of a remote controlled airplane which would be simple in nature and construction. In this work, Polyethylene /Aero Kote/Silk/Polyester Fabric coated aircraft wing was taken for analysis.

Keywords: Composite Aircraft wing, lift and drag, modelling, flow analysis

1. Introduction

Adarsh et al. (2012) [1] has studied about the stress analysis and fatigue life prediction for splice joint in an aircraft fuselage through an FEM approach. Aluminium alloy 2024-T351 material is considered for all the structural elements of the panel for fabrication of the aircraft body. Force due to cabin pressurization is considered as one of the critical load cases for the fuselage structure.

Fuselage experiences constant amplitude load cycles due to pressurization. Splice joints are used for the fuselage structure. Typical splice joint panel consisting of skin plates, doubler plate and a longitudinal stiffener is considered for the study. The project includes the stress analysis of a splice joint in a transport aircraft. A two-dimensional finite element-analysis is carried out on the splice joint panel. Distribution of fasteners loads and local stress field at rivet locations are studied using finite element analysis. The work involved the analysis of the splice joint using software's MSC/NASTRAN and MSC/PATRAN. A two-dimensional finite element-analysis is carried out on the splice joint panel. Distribution of fasteners loads and local stress field at rivet locations is studied from finite element analysis. The work also involves the modifications required to correct the boundary effects of the panel. The global finite element analysis of a segment of typical fuselage will be carried out. This global finite element analysis results will be bench mark for comparing the results from the splice joint panel analysis. Repeated finite element analysis is carried out to get the response of the parent structure (fuselage) at the joint location. The response of the splice joint is evaluated. The splice joint is one of the critical locations for fatigue crack to initiate. Hence prediction of fatigue life for crack initiation is carried out at maximum stress location.

Amarendra (2006) [2] conducted a study where the main objective of the research was to establish a link between critical riveting process parameters on the potential of fatigue damage in the joint. Aircraft fuselage splices are fatigue critical structures and the damage associated with these structures has been widely recognized as a safety issue that needs to be addressed in the structural integrity of aging aircraft. An effective means for structural evaluations of airworthiness of aging aircraft and obtaining essential data for evaluation of such type of fatigue cracking is airframe teardown inspections and laboratory fatigue testing of lap joint.

The Federal Aviation Administration and Delta Airlines teamed up in such an effort to conduct destructive evaluation, inspection and extended fatigue testing of a retired Boeing 727-232 (B727) passenger aircraft near its design service goal Preliminary visual inspection revealed a large number of cracks in the aircraft fuselage lap joint emanating from the rivet/skin interface. Most of these cracks were observed in the lower skin such that they could not be detected under an operator’s routine maintenance. The presence of these cracks was attributed to the sharp gradients of stress arising from contact between the installed rivet and rivet holes.

S.K. Bhaumik, M. Sujata (2008) [3] considered the failure analysis of various aircraft components due to fatigue and gave recommendations for the problems. After performing the failure analysis of the tail gearbox of the helicopter they concluded that due to location of sharp corners on the boss of tail gear multiple crack generated and they recommended to avoid sharp corners on the boss.

Hong-Chul Lee and BokwonLee (2007) [4] analyzes the failure of stainless steel bolts due to corrosion and residual stress in catia .Failure happened due to conjoint action of a surface tensile stress and corrosive environment. Finally they concluded that material of the clamp bolt should be changed into a more corrosion resistance material rather than frequently inspection. Jan Siegl, Ivan Nedbal(2009) [5] tried to improve the service life of aircraft bottom skin and stringer joint by introducing one more flange near the bottom flange of I-section. We can't stop the crack growth rate but by introducing one more flange at least we can increase the service life of structure.

B. Kosec, G. Kovacic (2002) [7] carried out work on fatigue failure and cracking of aircraft wheel rim. The wheel was made from 2014-T6 aluminum alloy. Inspection of air craft components are carried out by various methods. One of the method is non-destructive testing. They observed that during the manufacturing of tire a strong textile net is incorporated. In worn-out tires the net is in direct contact with the rim surface. Due to this high stresses developed and fatigue crack developed.

Lucjanwitek (2009) [8]Carried out work on wing-fuselage connector due to corrosion and worked on crack initiation and fatigue life analysis upper fuselage lugs and lower wing lug using Nastran patron.

Marcinciesilski, Jerzy Kaniowski (2009) [9] carried outwork on failure of wing bottom skin and stringer spliced joint due to fatigue load and observed crack rate growth due to plastic deformation through fractgraphic analysis MinLiao, Guillaume(2010) [10] carried out work on fatigue analysis for CF-18 component .he developed 3-dimensional finite element analysis model to simulate the loading applied in the lug test and determined the local stress-strain distribution. Based on the failure mechanisms, a simplified crack model was developed to estimate the crack growth and path of that crack.

L.Molent (2005) [11] developed a linear relation between the log of the crack length or depth and the service history by observing the fatigue crack growth and service loads and they observed how cracks have grown from semi and quarter-elliptical surface cuts, holes, pits and inherent material discontinuities.

Sridhar chintapalli, MostafaS.A.Elsayed (2010) [12] modified the stringers design. They modified z-section stringers which are used at top skin to withstand buckling to J-type stingers and also carried out damage tolerance design for bottom skin for crack growth.

Xiong and Bedair (1999) [13] mentioned about modeling procedures for the stress analysis of riveted lap joints in aircraft structure. Analytical methods have been developed based on the complex variational approach for lap joints with single or multiple rivet holes. The joined plates can be either metallic or composite materials. The stresses in the two joined plates and the rivet loads are determined.

Finite element analyses are conducted using the commercial packages MSC/Patran and MSC/Nastran. The complete description of an aircraft wing,components of a wing and static loads acting on the wing as shown inFig.1, Fig.2 and Fig.3.

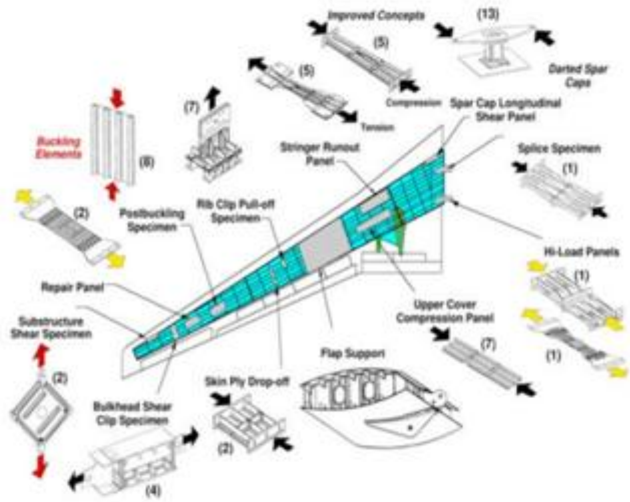

Fig. 1 Complete description of an aircraft wing.

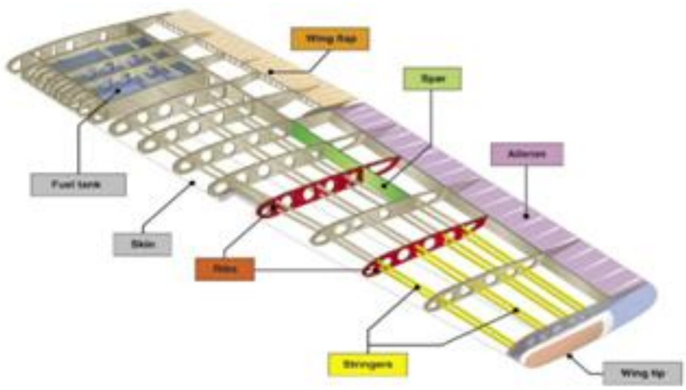

Fig. 2 Components of a wing.

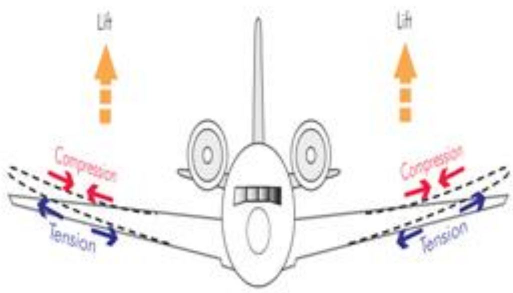

Fig. 3 Static Loads acting on wing

A radio-controlled (model) aircraft (often called RC aircraft or RC plane) is a small flying machine that is controlled remotely by an operator on the ground using a hand-held radio transmitter. The transmitter communicates with a receiver within the craft that sends signals to servomechanisms (servos) which move the control surfaces based on the position of joysticks on the transmitter. The control surfaces, in turn, affect the orientation of the plane. This paper includes the selection of the aerofoil its analysis, wing design, calculation of lift and drag force on the wing, and comparing with the theoretical values.

2. Designing

- **Determining the wing dimensions**

Set lift = target aircraft weight

=650grams + 100 grams

=750 grams

Lift = $0.5\rho v^2$ SC

Here

C = 0.8 to 1

S= wing area

Selected wing dimensions are 1000mm x 170mm

Table 1 Speed and Lift

Speed km/hr	Lift N
50	16.1
40	10.3
30	5.79

Aspect ratio

The range should be 4 to 6

AR= b/c =1000/170 = 5.88

- **Wing Positioning**

High wing configuration as it is easy to construct and stable.

- **Thrust**

Propeller size 8 x 6

Here 8inch is the diameter of the propeller and its pitch is 6in

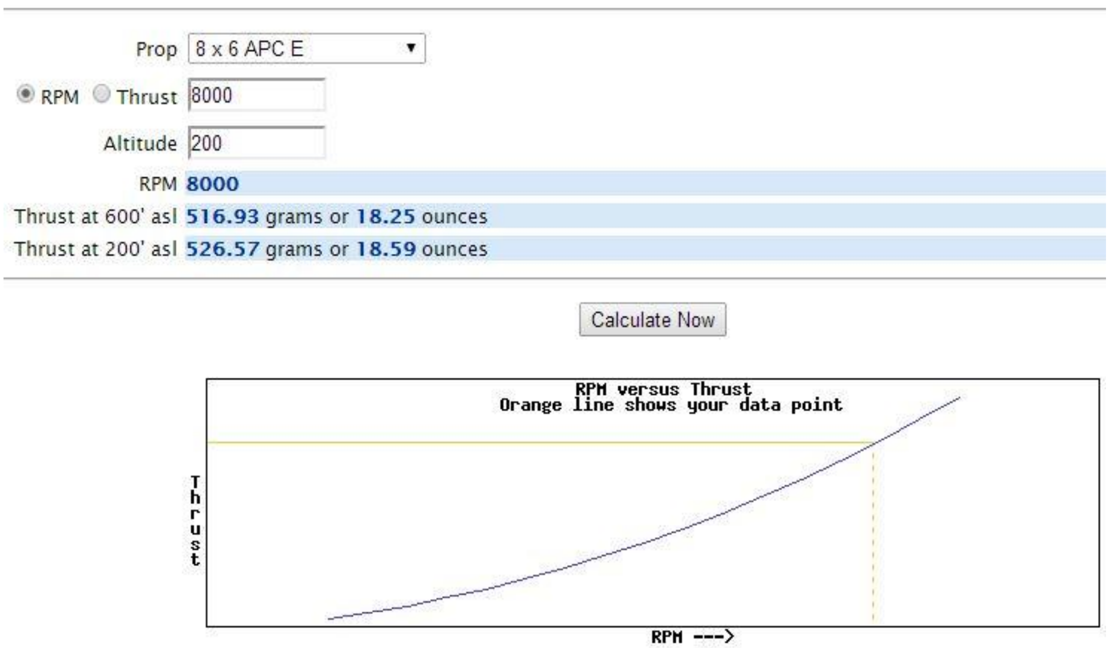

Fig. 4 RPM Vs Thrust.

3. Calculation of Reynolds number

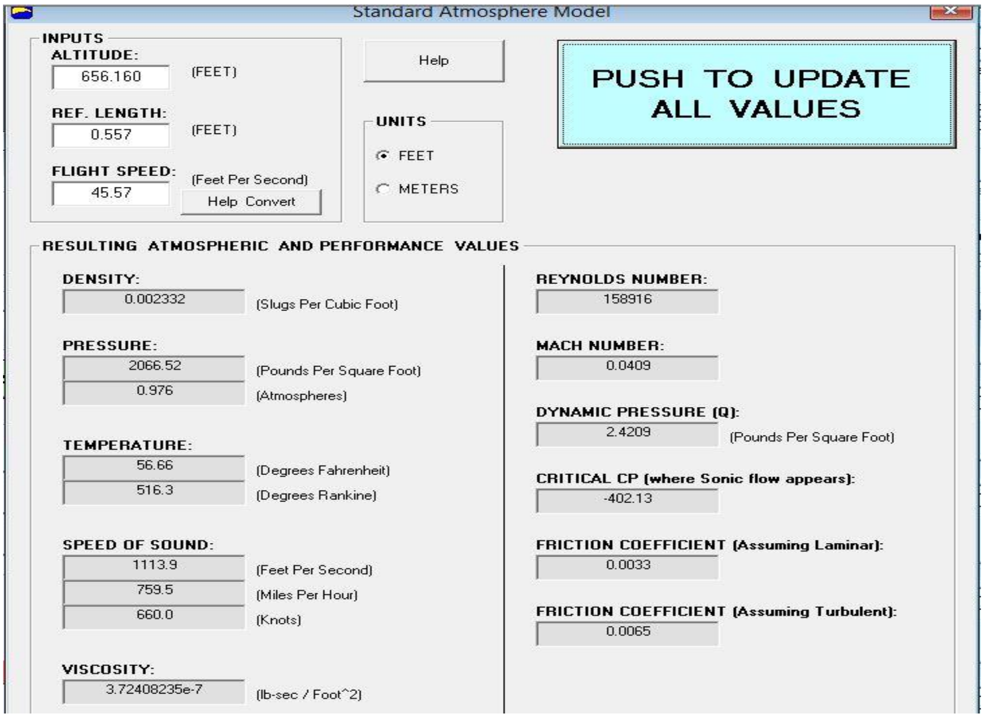

Fig. 5 Standard Atmosphere Model.

For altitude = 200 m =656.16 ft

Characteristic length(chord length) = 17 cm = 0.557 ft

Flight speed = 50 km/hr = 45.57 ft/s

The Reynolds number obtained is =158916

4. Construction Materials

Some of the materials used for the construction of RC airplane are

- Wood
- Balsa wood
- Wood veneer (obechi, poplar)
- Light plywood
- Fiberglass
- Carbon fiber
- Plastic / Foam
- Coroplast
- Polycarboanate resin (lexan)

- Molded polystyrene
- Extruded polystyrene (like depron or Styrofoam)
- Poly nylolene
- Expandable polypropylene

For, lift and drag force analysis, a layer of thin film is used to cover the basic construction of the wing. The film materials include

- Polyethylene thermoplastics (PET, bo PET, or mylar)
- AeroKote (adhesive film covering)
- Silk
- Polyester heat shrink fabric

The most used materials for constructions are Balsa wood which is strong but light. To reinforce the balsa wood construction rods or strips of carbon fiber are used. The covering film materials used are AeroKote, and heat shrink polymers.

Mass producing industries use anything from molded polystyrene or Styrofoam, with or without the reinforcement of carbon fiber rods.

5. Wing Configuration

Wing positioning

There are 3 types of wing positioning high, mid and low.

High winger was chosen as it is more stable than the others and also is easy to construct.

Wing dihedral

Dihedral angle is the upward angle from horizontal of the wings or tail plane of a fixed-wing aircraft.

The purpose of dihedral effect is to contribute to stability in the roll axis. It is an important factor in the stability of the spiral mode which is sometimes called "roll stability".

For the given input a polyhedral wing configuration is chosen as this polyhedral design is more stable but creates more drag then the other configuration, so it is suitable for the application of aerial photography.More specifically a tip dihedral configuration in polyhedral design is selected.

6. Various Aerofoil For Analysis

Basically there are 3 types of airfoils

- Flat bottom: most common in model aircrafts. Generate considerable amount of lift with low drag force

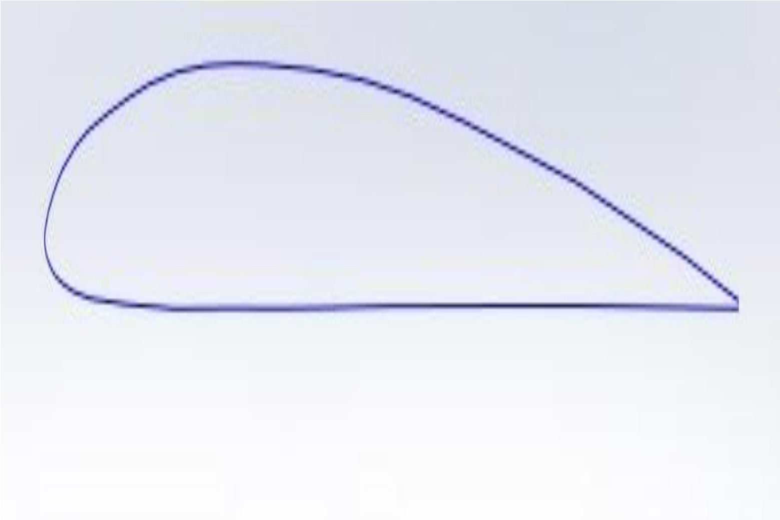

Fig. 6 Flat Bottom Airfoils.

- Semi symmetrical or symmetrical: generate considerable lift and is used in aerobatic aircrafts for better performance and high speeds.

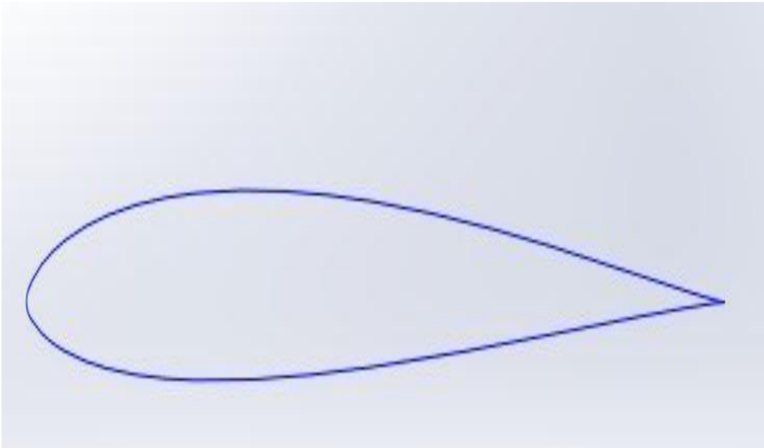

Fig. 7 Semi Symmetrical Airfoils.

- Under chambered: generate high lift at low speeds, generally used for sail planes.

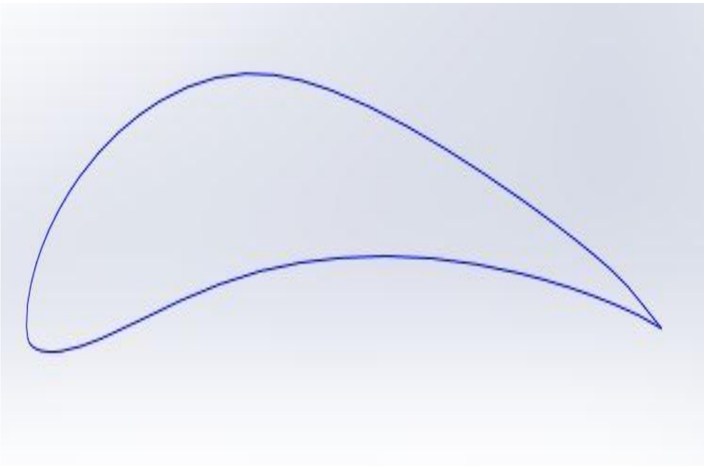

Fig. 8. Under Chambered Airfoils.

Flat bottom airfoil NACA 9000

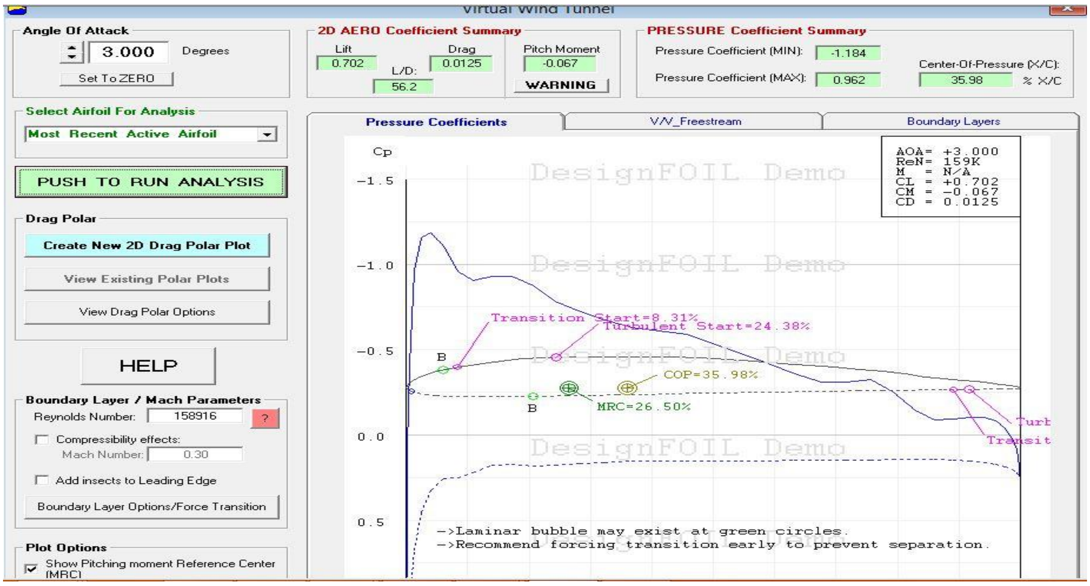

Fig. 9. Flat bottom airfoil NACA 9000.

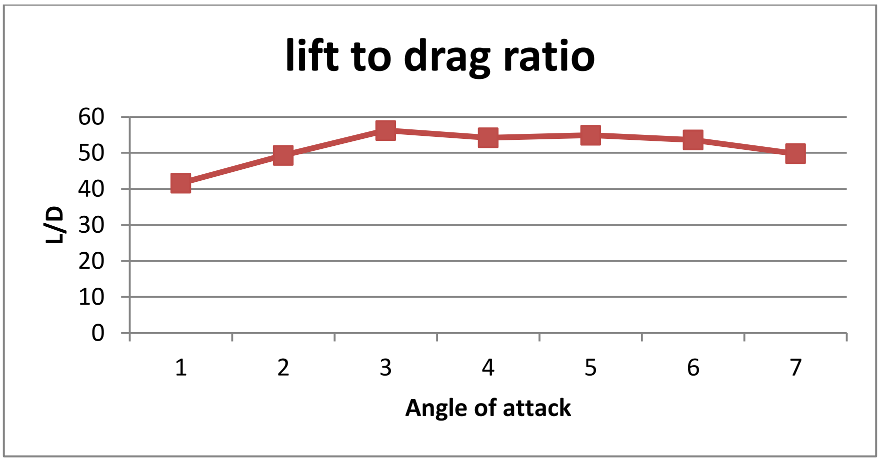

Fig. 10 Lift to Drag Ratio.

For an angle of attack of 3 degrees this airfoil is NACA 9000 has the lift to drag ratio of 56.2.

Semi symmetrical air foileppler 226

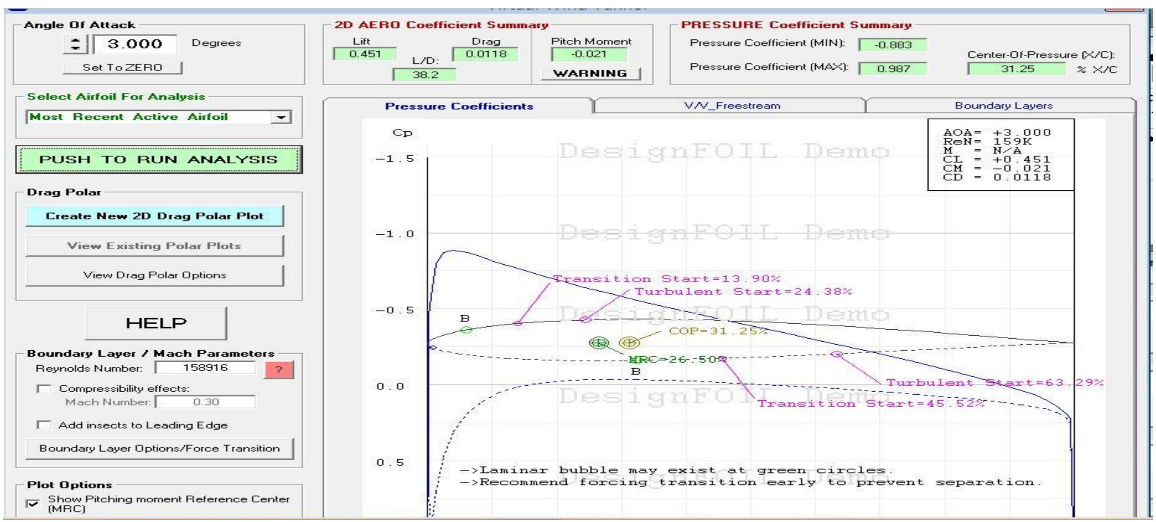

Fig. 11 Semi Symmetrical AirfoilEppler 226.

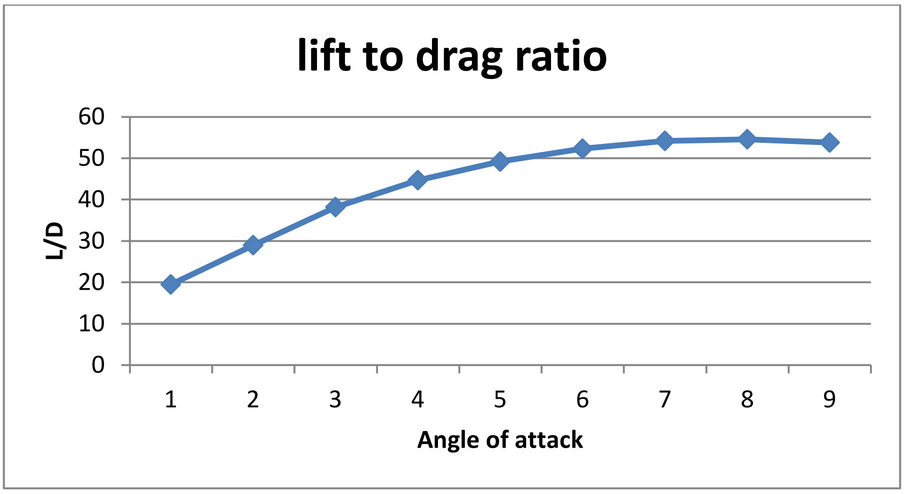

Fig. 12 Lift to Drag Ratio.

The fact that some drag coefficients do not follow tendency that the drag coefficient decreases as the Reynolds number increases can come from the fact that the grid is not exactly the same. Since the size of the geometry has been increases, the size of the base size cell must be increased too. Which can leads to some differences reflected in the cell numbers in the grid. It can be also the reality. For an angle of attack of 3 degrees, the airfoileppler 226 has a lift to drag ratio of 38.2, and maximum lift to drag ratio is at 8 degree which is 54.6.

Under chambered airfoileppler 420

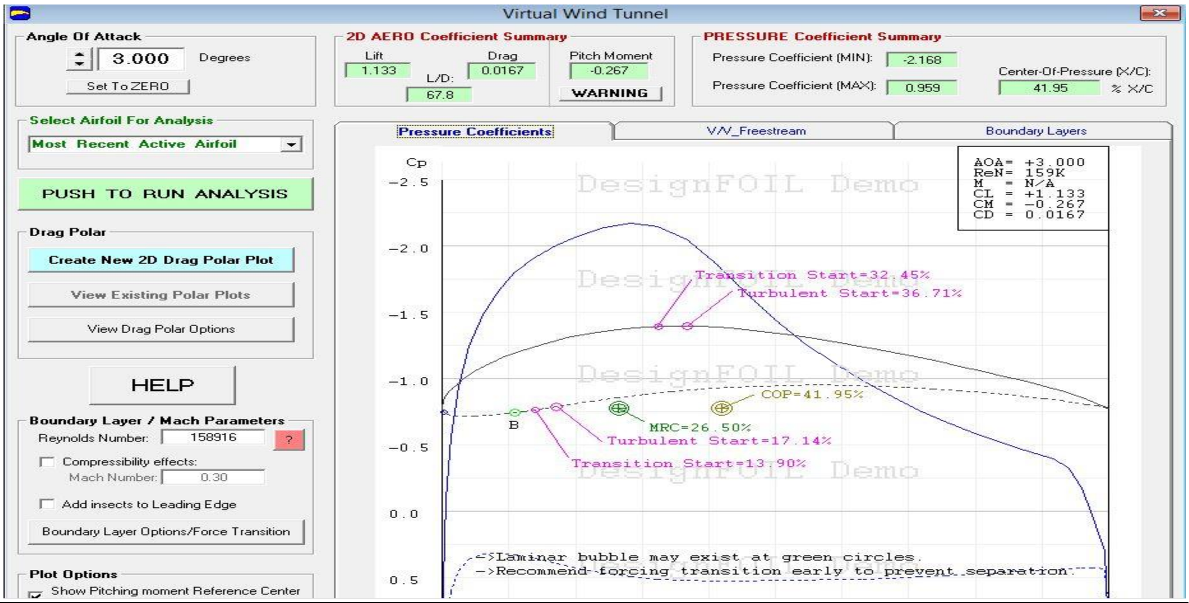

Fig. 13. Under chambered airfoileppler 420.

Table 2 Angle of Attack and Lift to Drag Ratio.

Angle of attack	Lift to drag ratio
1	66.9
2	67.5
3	67.8

4	67.6
5	67.2

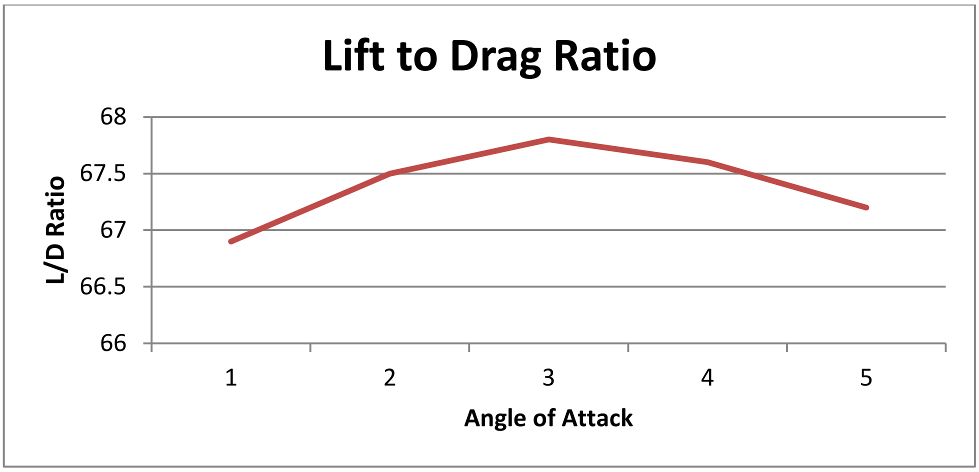

Fig. 14 Lift to Drag Ratio.

It is good to remark that the curve contains various cases and may be some refinement around precise Reynolds number can be interesting to adjust the tendency of the curve. Moreover, the Reynolds number for a flow around a high-speed is generally around the profile while here only one simulation has been done at this range of value. These results give a first idea of the evolution of the drag and lift coefficients with the Reynolds number for this geometry.

To better understand the reason for the decrease in drag, it is relevant to know the repartition of the drag between pressure drag and viscous drag. The results are showed in figure 9-14. From the graph the maximum l/d ratio is at 3 degrees of angle of attack, i.e. 67.8.

7. Conclusion

An attempt is made on composite coated aircraft wing. The results are plotted to analyse lift and drag forces. Thus the theoretical formulae hold good in wing designing. Hence through the selection of coating material, selection of airfoil, choosing the right thrust, wing dimensions, calculation of lift and drag forces a wing holds good for optimum a small, slow flying RC airplane.

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